Use of sub-surface drainage treatment for reclamation of saline soil: A case study of Kasabe Digraj village, District: Sangali, State: Maharashtra.

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Abstract:

Soil Salinity is a major environmental issue in Western Maharashtra mostly in irrigated areas. It is creating various problems such as loss in productivity, increased cost of cultivation and thus food security problems. It is necessary to find out practical solutions to overcome these problems. Sub-surface drainage treatment is one of the recommended treatment for soil salinity reclamation. In the present study, sub-surface drainage was carried out in the salt affected area for 5 months. The irrigation water analysis and soil analysis were carried out before and after the sub-surface treatment in the field. It is found that the treatment is effective for saline soil reclamation with certain conditions.

Key words: Sub-surface, drainage, soil salinity, irrigation

Introduction:

Soil, land and water are essential resources for the sustained quality of human life and foundation of agricultural development (Babu *et al.,* 2008). In the case of India, agriculture is a backbone of its economy in food production and employment point of view. It contributes about 17% of the Gross Domestic Product (GDP) and employing around 60% of its adult population in 2007 (Chahar and Vadodaria, 2008). After green revolution major emphasis was given on four elements of agriculture namely, improved quality seeds, fertilizers, pesticides and irrigation. The role of irrigation can be judged from the fact that, except in rare and limited areas, there has been no green revolution in India on un-irrigated land. As a result area under major and minor irrigation increased from 9.70 million ha during pre-plan to 42.77 million ha at the end of ninth plan. Area under minor irrigation also increased from 12.90 million ha in pre-plan period to 67.32 million ha at the end of annual plan 2000-01(Chahar and Vadodaria, 2008). On the other hand due to excess irrigation most of the area under irrigation is affected by the problem of soil salinity; and it became a major limiting factor for agricultural crop production (Kapourechal *et al.,* 2013).

Saline soil is a soil containing salts in it. The term salinity refers to the presence in soil and water of various electrolytic mineral solutes in concentrations those are harmful to many agricultural crops. Dominant salts in soils are generally consisted of NaCl, $MgCl_2$, $CaCl_2$, Na_2So_4, and $MgSo_4$. These salts are originally present in soil parent materials and released within soils as result of bedrock weathering. Salts are usually moved into the soil subsurface horizons and may either remain in the soil solutions or precipitate within the root zone (Kapourechal*et al,* 2013). Most common among these solutes are the dissociated cations Na^+, K^+, Ca^{2+} and Mg^{2+} and the anions Cl^-, SO_4^{3}, NO, HCO_3, and CO_3^{2}. In addition, hypersaline waters may contain trace concentrations of the elements B, Se, Sr, Li, SiO, Rb, F, Mo,Mn, Ba, and Al, some of which may be toxic to plants and animals (World Bank, 2000) The distinguishing characteristic of saline soil is an electrical conductivity of saturation soil extract of more than 4 dS/m at 25^0C (Richards, 1954).

Soil salinization process can be either natural or may be imposed by human activities. The latter is usually arises from irrigation in areas with low rainfall and high evaporation. In such conditions, the necessary steps are conducting leaching practices and/or performing a desirable drainage system (Kapourechal *et al.,* 2013).

Productive agricultural land is going out of cultivation because water logging and salinity caused by the raise of water table due lack of proper drainage are the major problem in the canal command areas. It is estimated that up to 20 % of irrigated land in the world is affected by different levels of salinity and sodium content (Fard *et al.,* 2007). Adoption of sub surface drainage technology is probably one of the best ways to increase resource use efficiency in order to increase crop production and sustain natural resources like soil and water in severely water logged saline soils (Babu *et al.*, 2008). Drainage maintains the productive capacity of soil by removing excess water, improving the soil moisture, improving the air circulation and reducing salt content and erosion (Chahar and Vadodaria, 2008).

Soil salinity is also a major environmental and agriculture issue in Maharashtra. According to Soil Salinity Research Institute about 1,77,093 ha of soil is affected due to salinity in the state of Maharashtra. Main factors which are responsible for increased soil salinity are excess and faulty irrigation methods, low drainage, high level of salt in water and dry climate. Cultivators are facing a foremost issue of drop in crop production due to soil salinity. In Maharashtra, District Sangali is one of the most affected district due to soil salinity.

If the natural drainage is insufficient to wash excess water and salts away from an area without raising the ground water table. It may be necessary to install an artificial drainage system for leaching of excess salts. Drainage system may be surface and sub-surface. Surface drainage is draining off excessive surface ponding where sub-surface is lowering the root zone accumulation and the water table. Out of various methods of drainage systems sub-surface drainage system will be most effective. Sub-surface drainage performed by fixing perforated PVC or clay tiles underground in a grade and draining an accumulated salt along with water to common outlet and then out of the field.

In the current study, land affected by salinity is taken for subsurface drainage treatment system by using clay tiles for removing excess salts from the soil. The sub-surface drainage programme was carried out for five months from August to December, 2011.

Materials and Methods:

- **Study area:**

The study area is village: Kasabe Digraj, Taluka: Miraj, Dist.: Sangali, State: Maharashtra, India located on the bank of Krishna river. Village receives average annual rainfall of about 453.78 mm mainly received in the period of monsoon i.e. from June to October. Climate is dry and characterized by hot summer and mild winter.

Total cultivable area of village is 1097.35 ha out of which about 568 ha. (51.76%) has been affected by salinity and it is increasing in day by day. Out of total affected area 325 ha area is under use of sub-surface drainage system for soil reclamation. The Krishna River is main source of water for irrigation and subsurface drainage.

The testing field was divided by saline wall of 1m depths on every side and then the area of testing was set to 9 m^2. Since, the groundwater around this site flows at about 0.4 m that is very shallow, the depth of drainage pipe was determined to 0.8 m.

- **Sampling:**

a) Water Sampling:

The water samples were collected and analyzed monthly at three sites; one was near the discharge, one within the trench and third was at the outlet point.

Sr.No.	Sampling Sites	Code
1	Water sample at the point of discharge	A
2	Water sample in between trench	B
3	Water sample at outlet of the farm	C

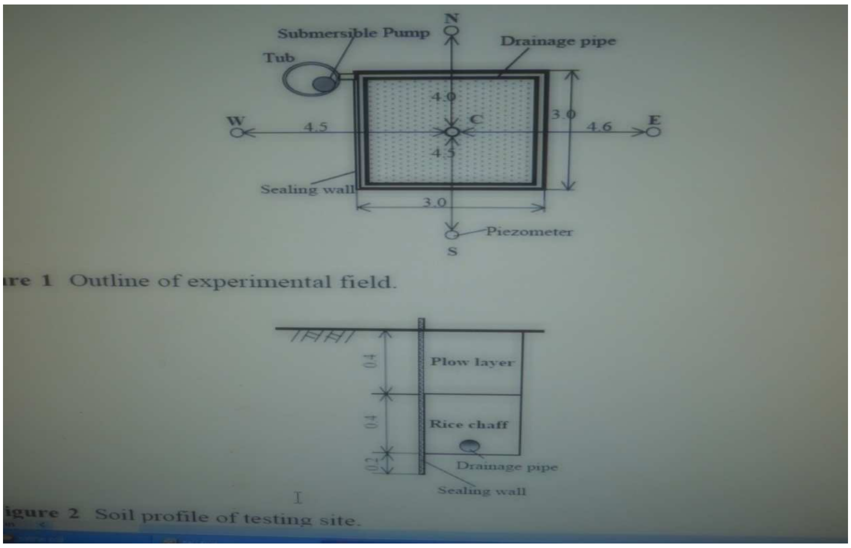


Figure 1: Arrangement of tile drainage in the field.

- **Chemical analysis:**

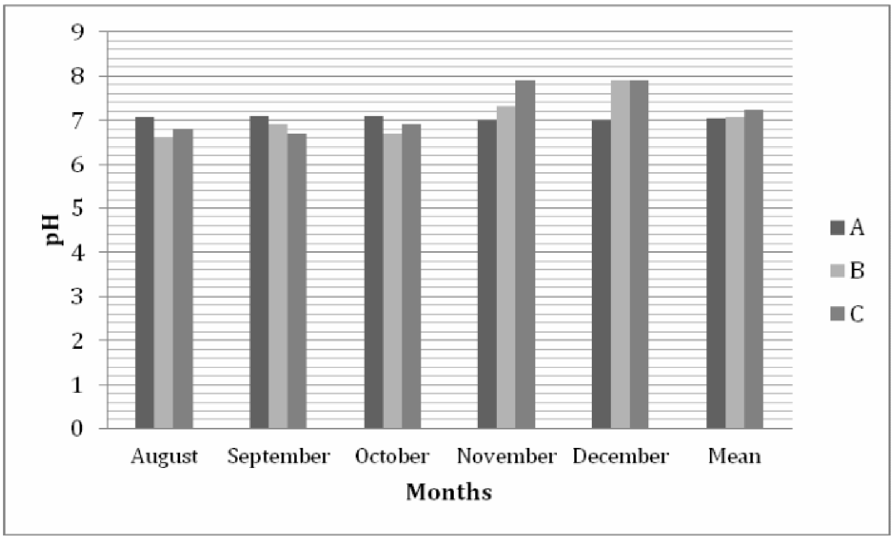
Major parameters were selected for the analysis of water and soil to study the changes in their water quality. The standard methods were followed for chemical analysis (APHA, 2005).

Results and Discussion:

The experiment was carried out for 5 months from August, 2012 to December, 2012. During the period of experiment water samples were collected monthly for the analysis purpose. Soil samples were also collected to see the difference between parameters before treatment and after treatment. Based on the analysis done following data is generated.

Sr. No.	Months\Site	A	B	C
1.	August	7.06	6.58	6.8
2.	September	7.1	6.9	6.71
3.	October	7.1	6.7	6.9
4.	November	7	7.3	7.9
5.	December	7	7.91	7.89
	Mean	**7.052**	**7.078**	**7.24**
	S.D.	**±0.050**	**±0.539**	**±0.601**

Table 1: Monthly variation in pH of the water during the period of treatment.



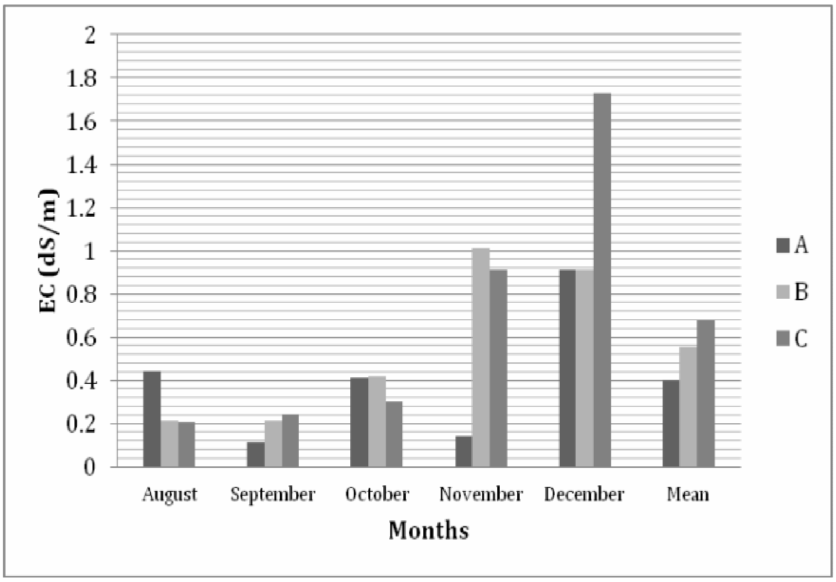
Graph 1: Monthly variation in pH of water at various sites during the treatment period.

It is observed that pH of water is neutral throughout the treatment period. It shows that the quality of water is good for irrigation and to carry out sub-surface drainage treatment. There is a slight variation in the pH of water which is 6.5-8.4 and within the range of standards for irrigation water.

Sr.No.	Month/Site	A	B	C
1.	August	0.44	0.211	0.204
2.	September	0.11	0.211	0.244
3.	October	0.41	0.417	0.301
4.	November	0.144	1.01	0.913

Sr.No.	Month/Site	A	B	C
1.	August	0.44	0.211	0.204
2.	September	0.11	0.211	0.244
3.	October	0.41	0.417	0.301
4.	November	0.144	1.01	0.913
5.	December	0.914	0.911	1.73
	Mean	**±0.403**	**±0.552**	**±0.678**
	S.D.	**0.322**	**0.383**	**0.655**

Table 2: Monthly Variation in E.C. (dS/m) of the water during the treatment period.

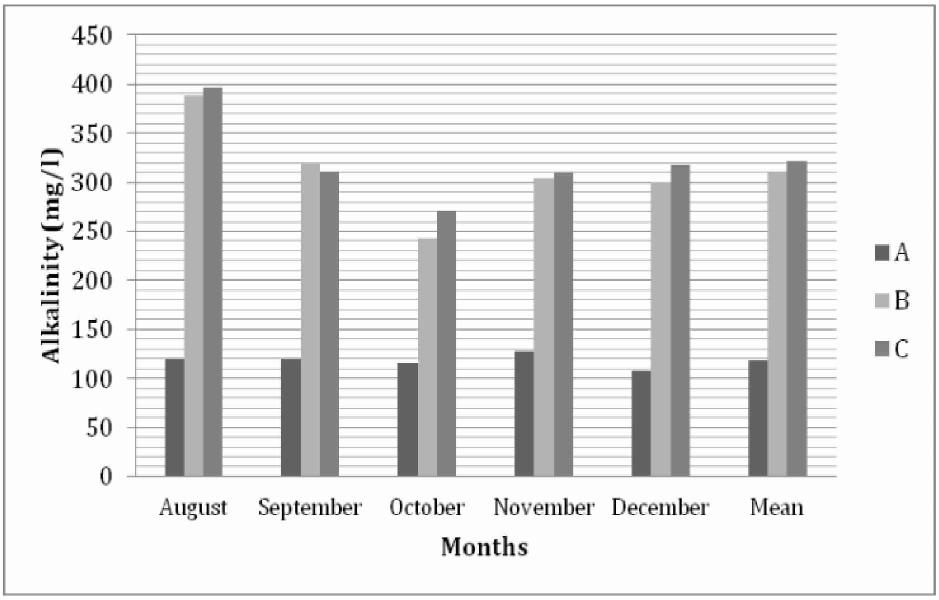


Graph 2: Monthly variation in EC of the water during the treatment period .

Electrical conductivity found in the irrigation water is within the range of standard i.e. 0.7-3.0dS/m. EC is the most important parameter to estimate the salt content of soil. Leaching level of 37 % and irrigation water salinity of 4 dS/m reducing initial soil salinity up to 56 %, was the best treatment (Fard *et.al.*, 2007). Thus it is necessary to use good quality of water for good results. Water used here is of good quality.

Sr.No.	Month/Site	A	B	C
1.	August	120	388	396
2.	September	119	319	311
3.	October	115	242	271
4.	November	128	304	310
5.	December	108	300	318
	Mean	**118**	**310.6**	**321.1**
	S.D.	**±7.314**	**±52.257**	**±45.702**

Table 3: Monthly Variation in Alkalinity (mg/l) of the water sample of saline soil of the study area.

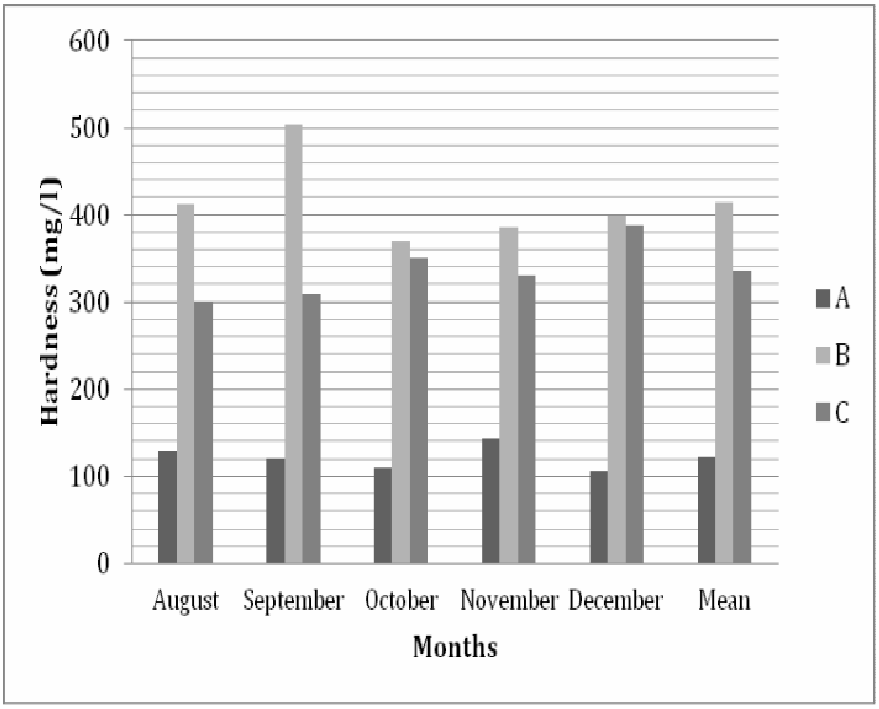


Graph 3: Monthly average variation in Alkalinity (mg/l) of the water during the treatment period.

As per the observations it is can be concluded that the alkalinity of water gets increased subsequently from discharge point to outlet point. It shows that, alkalinity present in the soil get washed away by water.

Sr.No.	Month/Site	A	B	C
1.	August	130	412	300
2.	September	120	504	310
3.	October	109	370	351
4.	November	144	386	330.2
5.	December	106	398	388
	Mean	**121.8**	**414**	**335.84**
	S.D.	**±15.626**	**±52.630**	**±35.123**

Table 4: Monthly Variation in Hardness (mg/l) of the water during the treatment period.

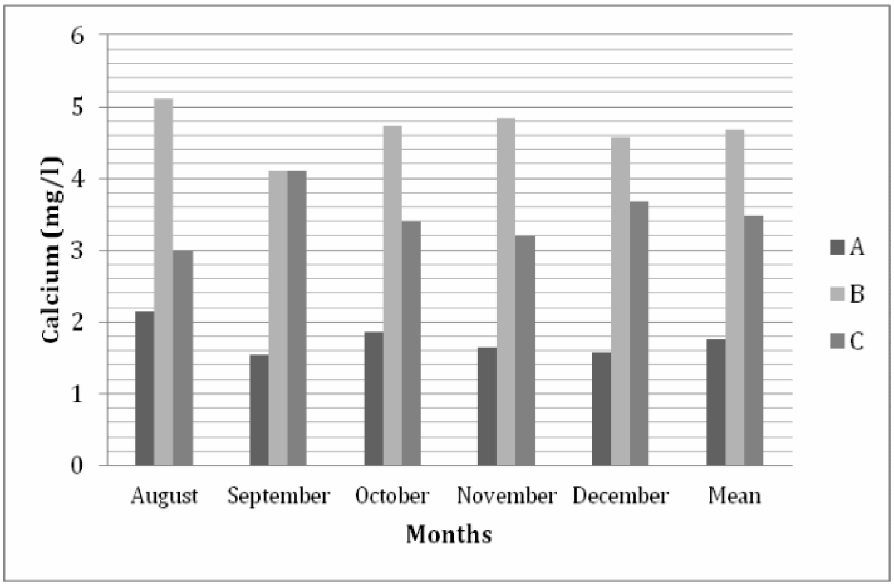


Graph 4: Monthly variation in Hardness (mg/l) of the water during the period of treatment

Hardness of the water used for sub-surface drainage gets increased from inlet to outlet. Increased amount of hardness shows the increase concentration of salts which indicates the leaching of salts from soil.

Sr.No.	Month/Site	A	B	C
1.	August	2.14	5.1	3
2.	September	1.54	4.1	4.1
3.	October	1.86	4.74	3.4
4.	November	1.64	4.84	3.2
5.	December	1.58	4.58	3.68
	Mean	**1.752**	**4.672**	**3.476**
	S.D.	**±0.249**	**±0.371**	**±0.429**

Table 5: Monthly Variation in Calcium (mg/l) of the water during the treatment period.

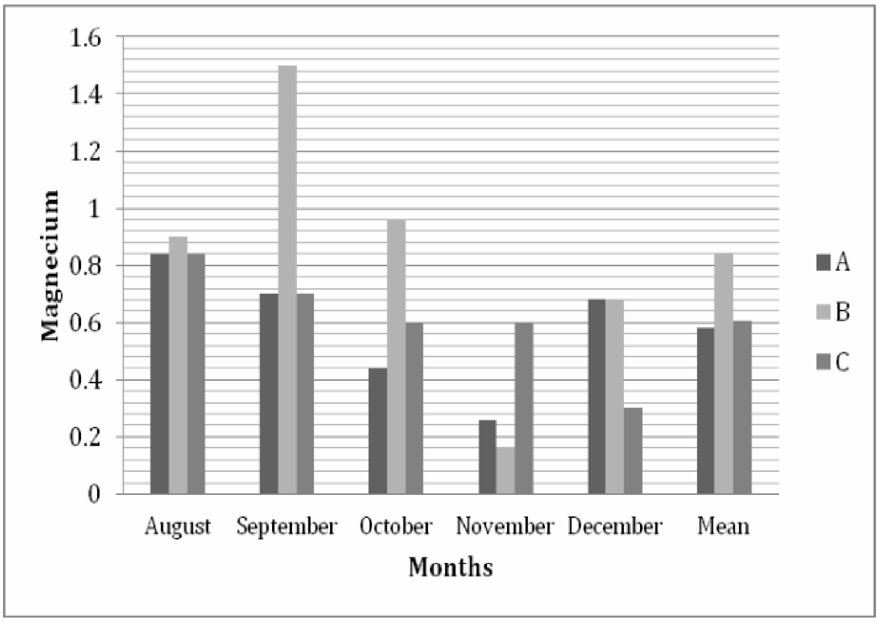


Graph 5: Monthly variation in Calcium (mg/l) of the water during the treatment period.

The concentration of Calcium ions is more at the site 'B' than 'A' which is middle in the field in between trench. It again decreases up to the site 'C'. It shows wash down of Calcium ions and again absorption of some of them. But, final concentration of calcium is more than first site.

Sr.No.	Month/Site	A	B	C
1.	August	0.84	0.9	0.84
2.	September	0.7	1.5	0.7
3.	October	0.44	0.96	0.6
4.	November	0.26	0.16	0.6
5.	December	0.68	0.68	0.3
	Mean	**0.584**	**0.84**	**0.608**
	S.D.	**±0.231**	**±0.485**	**±0.198**

Table 6: Monthly Variation in Magnesium (mg/l) of the water during the treatment period.

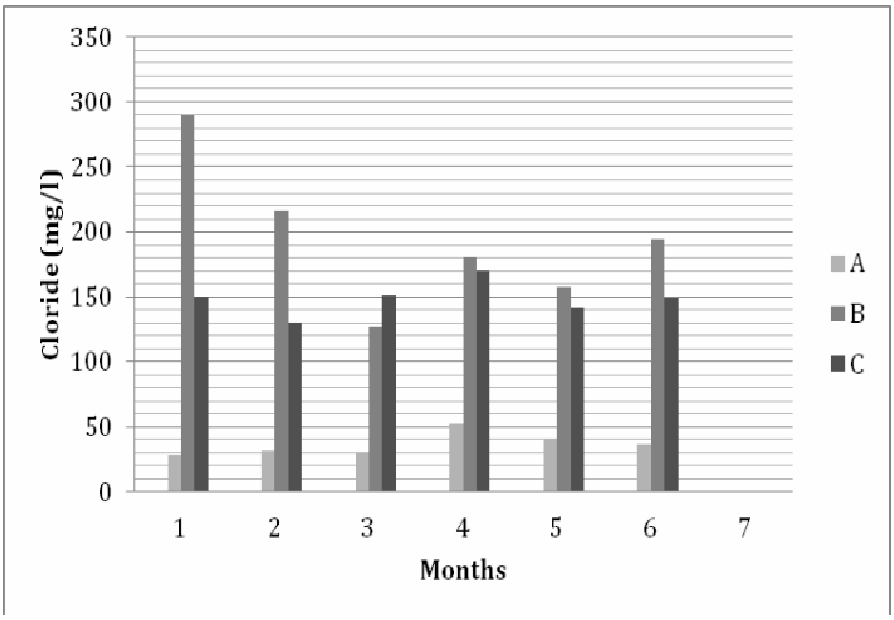


Graph 6: Monthly variation in Magnesium (mg/l) of the water during the treatment period.

The Magnesium ions concentration is also more at the site 'B' than 'A'. It again decreases up to the site 'C'. It shows wash down of Magnesium ions and again absorption of some of them. But, final concentration of calcium is more than first site.

Sr.No.	Month/Site	A	B	C
1.	August	28	290	150
2.	September	31.5	216	130
3.	October	30	127	151
4.	November	51.8	181	170
5.	December	40	157	142
	Mean	**36.26**	**194.2**	**148.6**
	S.D.	**±9.817**	**±62.703**	**±14.621**

Table 7: Monthly Variation in Chloride (mg/l) of the water sample of saline soil of study area

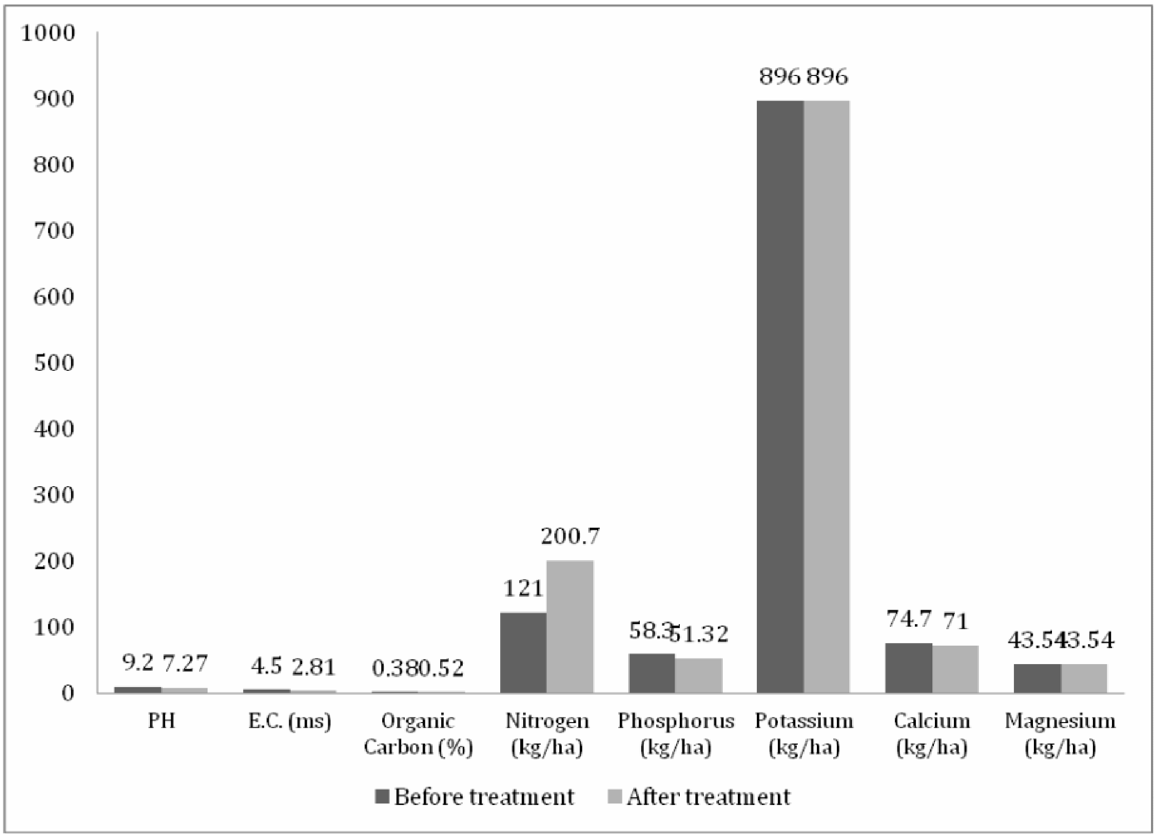


Graph 7: Monthly Variation in Chloride (mg/l) of the water during the treatment period.

Chloride content of water used for treatment is goes on increasing and then again lowers down at the point of outlet.

Sr. No.	Parameter	Before treatment	After treatment
1	P^H	8.7-9.2	7.27
2	E.C. (ms)	4.5	2.81
3	Organic Carbon (%)	0.38	0.52
4	Nitrogen (kg/ha)	121	200.7
5	Phosphorus (kg/ha)	58.3	51.32
6	Potassium (kg/ha)	896	896
7	Calcium (kg/ha)	74.7	71
8	Magnesium (kg/ha)	43.54	43.54

Table 8: Physico-chemical parameters of soil of affected area before and after treatment.



Graph 8: Physico-chemical parameters of soil of affected area before and after treatment.

It is observed that there is a significant change in two major physical parameters of soil, those are p^H and electrical conductivity (E.C.) of affected area. Reduction in pH is observed from 8.7 to 7.27 and in E.C. from 4.5 dS/m to 2.81 dS/m after sub-surface drainage treatment. pH and E.C. are the most important parameters in determining salinity of soil. Also there is a noticeable increase in organic Carbon and Nitrogen content of soil after sub-surface treatment. There is not much difference observed in other major and minor nutrients like Phosphorus, Potassium, Calcium and Magnesium. According to soil salinity point of view, pH and E.C. are key parameters in determining the salinity. Decrease in these two parameters shows satisfactory results of the treatment.

Conclusion:

As per documentary evidences, subsurface drainage has been experimented in India for the last 130 years or so (Kaledhonkar *et al.,* 2009). In the experiment sub surface drainage treatment carried out in salt affected area along with the water and soil analysis, it is observed that the treatment is quite effective and it shows satisfactory results. Leaching of salts in the form of ions is good to reduce soil salinity. Leaching can decrease soil salinity effectively by improving the quality of irrigation water (Fard *et.al*., 2007). Thus sub-surface drainage can be one of the most effective treatments for reclamation of saline soil if the water used for drainage purpose is of good quality.

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